

the same stimuli give rise to the same sensation. That certain pairs of *spectral rays*, red and blue-green, for instance, produce grey or white is quite another fact, and may possibly be explained in the following way. All the pairs of spectral rays which together make grey or white are far apart from each other in the spectrum, and are not present in rays given out by any saturated pigment. Thus red and green rays stimulate the retina when any yellow object is observed, a pigment which gives out, in addition, the blue-green rays, is of a pale whitish-yellow. Thus, while pigments which give out red and green rays appear more yellow, those which give out red and blue-green rays appear less so and approach the primitive achromatic sensation.

Without knowledge of the changes which actually take place when light falls upon the retina, and before therefore the subject is really opened up, scientific observers have brought forward complete theories of vision. Both in the theory of Young and in that of Hering the visual organ is "conceived" by them, and in the absence of facts these theories can only be looked upon as tentative. In this paper an attempt has been made to arrange new facts by the side of old ones, in order that they may be understood the better. Beyond the point at which it is possible to explain a subject in terms of what we already know in physics and physiology, no progress has been attempted. Such attempts have in other departments of physiology proved too often unsuccessful to encourage effort in a subject the threshold of which every physiologist will agree that we are only about to enter.

"The Har Dalam Cavern, Malta, and its Fossiliferous Contents." By JOHN H. COOKE, F.G.S. With a Report on the Organic Remains, by ARTHUR SMITH WOODWARD, F.L.S., F.G.S., F.Z.S. Communicated by HENRY WOODWARD, LL.D., F.R.S., V.P.G.S. Received February 2,—Read February 23, 1893.

(Abstract.)

The Har Dalam cave is situated in the eastern part of the island of Malta, near Marsa Scirocco Bay. The headlands around the bay are composed of Lower Coralline Limestone, capped by *Globigerina* Limestone. Numerous valleys intersect the land at right angles to the coast line, forming small creeks and bays at their embouchure.

The Har Dalam gorge, in which the cavern is situated, is a valley of erosion which carries off the drainage of the land above, and was no doubt excavated at a time when the rainfall of Malta was much greater than at present. This is indicated by the heaps of rounded

boulders and water-worn *débris* in the gorge, and by the groovings and flutings on the rocks along its steep sides.

The cavern is situated 500 yds. from the shore on the north side of the gorge, and consists of a main gallery 400 ft. in length, when it ramifies in various directions, forming smaller tunnels and chambers, which follow the jointings and the bedding planes of the rock. One branch fissure is 250 ft. in length, 15 ft. high, and just wide enough for a man to pass along it, widening out at intervals into dome-shaped rock chambers. Two of the other galleries are of considerable length, but most do not exceed 20 ft. in length. One was traced for 35 ft., and ended in a fissure; another, having a N.E. course for about 100 ft., ended in a rounded extremity. They were filled to within 1 ft. 6 in. or 2 ft. of the roof with a reddish plastic clay, kept moist by percolation from the roof. The sides of all the galleries are in places encrusted with a stalactitic lining, generally obscured by a coating of clay.

The mouth of the main gallery is 26 ft. wide and 10 ft. high, and has been used during late years as a cattle shelter, the entrance being walled up and provided with a doorway. It widens inwards into a spacious chamber 60 ft. wide and 17 ft. high, having a branch to the right hand extending for 10 ft., but filled to the roof with boulders. The total length of the cave, including the terminal fissure, is 700 ft. The roof and sides are irregularly and smoothly arched, but the height and width vary considerably, as shown by section and plan.

The stalactites which largely covered the roof have been mostly broken off by later torrential action, but the larger ones, 3 to 6 ft. in circumference, still remain *in situ*. Raised bosses of stalagmite on the floor correspond with the stalactites above. These stalagmitic bosses were observed at three different levels, each being covered by fresh alluvial deposits, indicating the intermittent character of the floods that invaded the cavern and the long periods that elapsed between them.

The present floor of the main gallery is fairly even. After entering there is a rapid descent, followed by a gentle rise to the extreme end of the gallery. The deposits met with vary considerably in different parts of the cave. At the furthest extremity they are mainly composed of red loam; in the middle, of large boulders and broken stalactites and old pottery enclosed in clay; towards the entrance, of a grey indurated marl, with abundant remains of land shells, roots of plants, bones of Deer, and boulders. The cave is everywhere strewn with enormous quantities of water-worn boulders similar to those met with so abundantly in the valleys and gorges of the islands.

Excavations show that the sides of the cave slope inwards, and form a trough-like rift of very irregular outline and much broken and fissured.

It is the author's opinion that the cave owes its present dimensions to the same torrential waters which widened the gorge and moulded and channeled the rocky sides of both.

It must have been repeatedly submerged, and its sides became coated by the muddy waters with the clay now adhering to them.

These torrential inundations no doubt caused the death and entombment of the Hippopotami, Deer, and other animals, whose remains, commingled with boulders and broken-off stalactites, attest the turbulence of the waters.

Eight excavations were made in various parts of the cavern, of which ground plans and sections are given by the author.

Trench I was opened on the right-hand side of the main gallery, 350 ft. from the entrance.

It was 24 ft. in length, 8 to 9 ft. in width, and 8 ft. 6 in. in depth. It gave the following deposits *in descending order* :—

A. Floor earth with stones, clay, and boulders (unstratified), 6 in.

B. Red clayey loam (3 ft. in thickness), containing bones of Hippopotami (*H. Pentlandi*), teeth and bones of *Cervus*, the bones very irregularly distributed; also some fragments of ancient pottery.

C. Layer of black earth (4 in. thick), like coarse oatmeal, quite unfossiliferous, but very persistent throughout.

D. Dark red plastic clay (1 ft. 6 in. thick), with many remains of *Hippopotamus Pentlandi* in good preservation and less disassociated. Although well preserved, however, they were so soft from the dripping of water that they would not bear handling.

E. Layer of reddish clay (1 ft. thick) full of bones, jaws, and teeth of a small *Hippopotamus*, cemented together by calcareous infiltrations, and forming an ossiferous breccia (very compact). A single molar of *Elephas (E. mnaidriensis)* was found here.

F. Stratum of stiff yellow plastic clay (2 ft. thick), unfossiliferous, but enclosing a few angular fragments of limestone fallen from the roof.

Trench II, also on the right-hand side of the cave, but nearer to the entrance, showed a series of ten regularly stratified layers, mostly alternating layers of clay and grey calcareous marly earth.

The upper layers contained no organisms, but the red-marly earth contained numerous remains of antlers of Deer and abundance of land shells (but mostly broken); beneath this series, and separated by a seam of marly earth, is a bed of red clay (3 ft. thick), containing antlers, teeth, and bones of Deer, and remains of *Hippopotamus*, very well preserved.

Trench III, midway, in the centre of the floor of the cave: this trench reached the rock at 6 ft. 6 in. from the surface. Immediately in contact with it is a layer of dark red clay, with broken bones of

Hippopotamus, but no Deer. The fissures in the rock itself also contained remains of *Hippopotamus* firmly wedged and cemented into them.

Trench IV, also in the centre of the cave, exhibited a series of deposits similar to those in Nos. I and III.

Layers A, B, and C, in descending order, contained no organic remains, but in layer D (indurated brick-red earth), which appears to be the basal layer of C, composed of its heavier materials, sorted by water, are remains of *Hippopotamus* and *Cervus* intermixed in pell-mell confusion. Amongst these remains Mr. Arthur Smith Woodward has determined the third metacarpal of Man. It was found at depth of 3 ft. 6 in. from the surface, and underlying a layer containing pottery. It is probably of great antiquity, being extracted from one of the earliest layers in the cavern. The layer beneath contains bones of *Cervidæ* and *Hippopotami*, but much broken.

Trench V was in a rocky fissure on the left-hand and furthest from the entrance of any of the trenches. It was excavated to a depth of 8 ft., but few organic remains were met with in it; there were many limestone boulders, some fragments of pottery, and several pieces of bones of *Hippopotamus*.

Trench VI, made on the left hand, 50 ft. from the entrance, is interesting because, in layer E, consisting of light gray clay and loam, with a few antlers, teeth, and bones of *Cervus*, was found the first Carnivore yet met with in Malta; represented by a jaw and several canines of *Ursus*.

In the layer beneath were numerous bones and teeth of the small *Hippopotamus*.

Although Admiral Spratt and Dr. Leith-Adams refer to the probable presence of Carnivora (from the gnawed condition of the bones in the Zebbug gorge), these are the first remains ever met with.

Trench VII was cut in a small branch cavern, running about 15 ft. into the rock at right angles to the main gallery, about 20 ft. from the main entrance.

Here, beneath a mass of boulders, was a layer of dry black earth, intermixed with grass, and fragments of pottery.

The layer beneath contained large blocks of limestone embedded in light friable marl, with great quantities of shells of *Helices*, jaws and bones of Sheep, &c.

Trench VIII, made within a walled enclosure 30 ft. from the entrance, was not rich in organic remains; but antlers and limb-bones of Deer and remains of *Hippopotamus* marked the corresponding layers met with in the other trenches.

The author concludes that the Har Dalam Valley is identical in its characteristics with the other valleys and gorges of Malta and Gozo, and that they all owe their origin to analogous causes: chiefly, he

thinks, to the action of marine erosion during a period of depression and of re-elevation; but *not* altogether to this cause.

The limited extent of the present land area, and of the annual rainfall it enjoys, would certainly not afford fresh water for a stream sufficient to cut out these gorges (often hundreds of feet in vertical depth). The author therefore considers they must date back to a period when these islands formed part of a much larger (indeed a continental) area, and that the rainfall must have been *much greater* than it is at the present time.

That during periods of torrential rains entire herds of Herbivora must have been drowned, and their carcasses swept into the gorge, and thence into the Har Dalam and other caves, where their remains were embedded.

In evidence of the great antiquity of these deposits, he points to the fact that the mouth of the cave is now 40 ft. above the bed of the small stream which, in rainy weather, flows through the gorge, and that no torrential waters now sweep through it; and, further, that the cutting down of 40 ft. of rock must have been an extremely slow and gradual process, and have taken place since the last cave layer was deposited.

Of the pottery, two well marked kinds were observed: the one, a rude, coarse, unornamented fabric; the other, finer in texture, and characterised by markings similar to those found on ware which occurs in tombs at Malta, and known to be of Phœnician and Punic origin.

The earlier kind is within 2 or 3 ft. of the surface; the later, only in the superficial layers.

Report on the Organic Remains. By ARTHUR SMITH WOODWARD, F.L.S., of the British Museum.

I. CAVE EARTH.

Ursus arctos (?).

The only remains of Carnivora discovered in the cave earth (Excavation No. VI, layer ii) comprise the imperfect left mandibular ramus and left lower canine of a small Bear, and another canine tooth equalling in size that of a Wolf. The mandibular ramus of the Bear belongs to a fully adult, perhaps aged animal, the permanent dentition being well worn; and the detached canine indicates a mandible of the same size. There is a small socket behind the canine for pm. 1; and pm. 4 is well developed, but without any inner tubercle beyond a rudiment anteriorly. The length of the diastema is 0·038, and the teeth preserved measure in length respectively as follows* :—

* All measurements are given in decimal fractions of the metre.

pm. 4.	m. 1.	m. 2.
0.014	0.023	0.025

It is impossible to determine a species of *Ursus* by the imperfect detached mandible; and the only certain statement that can be made

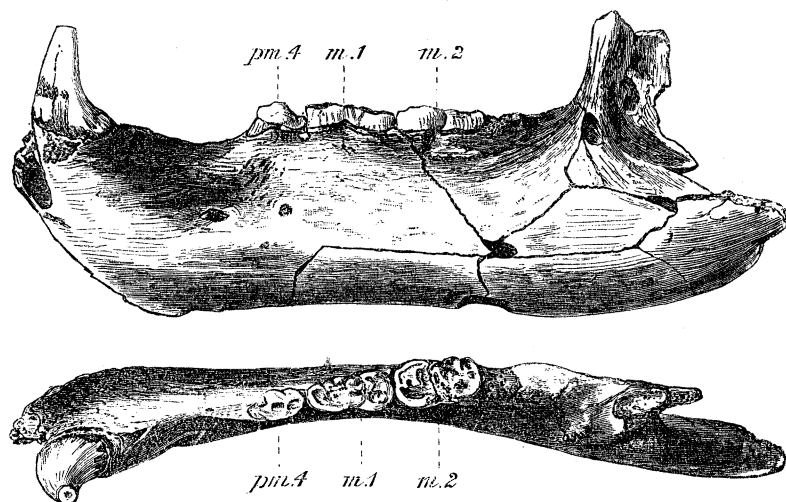


FIG. 1.—Left Mandibular Ramus of *Ursus arctos* (?); one-half natural size.

in reference to the present fossil is that it does not represent a dwarfed form of the extinct Cave Bear. This is proved by the comparatively simple character of pm. 4. The specimen agrees precisely in size, form, and proportions with the mandible of a common Brown Bear (*Ursus arctos*) in the British Museum numbered 218, *d*; and hence the Maltese form may be provisionally assigned to this species until the discovery of further remains. The jaw is much smaller than those from the Gibraltar caverns assigned by Busk to a variety between *Ursus arctos* and *U. fossilis*.

Canis sp.

The small canine tooth already referred to belongs to the left side of the mandible, and probably represents a species of *Canis* equalling the Wolf in size. Whether or not it is referable to a domestic animal is as yet indeterminable.

Elephas mnaidriensis.

Remains of Elephants are very rare in the Har Dalam cavern only an imperfect humerus and a molar tooth having been dis-

covered. Of the humerus, which belongs to the left side, the distal two-thirds of the shaft is alone preserved without either extremity ; and it can only be said that the bone indicates an animal of the size of *Elephas mnaidriensis*. To this species, however, may be ascribed with certainty the molar tooth, which resembles in all respects the upper molar 2, as described by Leith Adams. The tooth is worn and fixed in a fragment of the jaw, but its anterior portion has been broken away beyond the fourth plate.

Hippopotamus Pentlandi.

Bones and portions of dentition of *Hippopotamus* form nearly the whole of the collection of remains from the cave earth ; and it is noteworthy that nearly all these remains pertain to adult animals. They are much broken, and very similar in character to the bones and teeth of *Hippopotamus Pentlandi* discovered by Dr. Falconer in the Grotta di Maccagnone, Sicily. There can be no hesitation, indeed, in assigning the Maltese form to this species ; and the following few maximum measurements, made so far as the fragmentary bones will allow, indicate its small dimensions as compared with *H. amphibius* :—

Length and breadth of glenoid facette of scapula..	0·085 × 0·073
Width of trochlear articulation, distal end of humerus ..	0·09
Length of radius	0·235
Width of proximal articulation of radius	0·083
„ distal „	0·110
Length and breadth of acetabulum	0·079 × 0·085
Width of proximal end of femur	0·155
„ distal articulation „	0·14
„ proximal articulation of tibia.....	0·146
Astragalus	0·09 × 0·075 × 0·05
Length of calcaneum	0·17

Cervine Remains.

From a superficial layer of the cave earth in excavation No. IV, numerous much mineralised remains of Deer of various sizes were obtained. All the bones and antlers are rolled and too fragmentary for specific determination ; but the majority may well have belonged to the Barbary Deer, of which there is good evidence in the overlying deposit. Several fragments prove that the antlers were not shed specimens, and one base exhibits the insertion of two brow tynes such as characterise the adult *C. elaphus*.

Other fragmentary Cervine remains, including one pedicle and burr of antler, were discovered in the cave earth in Excavation No. VI

(layer iii), in the same condition as the associated bones of *Hippopotamus*, and bones of Deer also occurred in association with the mandible of Bear noticed above (Excavation No. VI, layer ii).

Human Remains.

A single human metacarpal III is also contained in the collection from the superficial layer of cave earth in Excavation No. IV. It is mineralised apparently to a somewhat less extent than the associated bones of animals.

II. SUPERFICIAL DEPOSITS.

Man and Domestic Animals.

Associated with the rude pottery discovered in the surface deposit in Excavations Nos. II and IV are various traces of a small Pig and a Goat or Sheep, besides a single tooth of *Bos*. A Deer larger than the variety of Barbary Deer mentioned below is also represented by numerous limb bones and some teeth. In an equally superficial layer in Excavation No. VI there is a single metatarsal of a Dog as large as a Wolf, and an imperfect cannon bone of a very small Horse or Donkey.

Bones of Bats have evidently been accidentally introduced, and there are a few fragmentary rolled remains of *Hippopotamus* derived from the Cave Earth. A few fragments of a small land Chelonian also occur.

Cervus elaphus, var. barbarus.

The remarkable accumulation of bones in the dry stalagmitic superficial layer in Excavation No. VI consists almost entirely of remains of a small Deer in all stages of growth, perhaps even from the unborn foetus onwards. None of the bones exhibit evidence of gnawing or artificial fracture, and although some of the shed antlers appear to have been gnawed, it is probable that these have been bitten by the Deer themselves in accordance with their usual custom.

Nearly all the antlers are distinctly shed specimens, and the largest complete example measures 0.63 in total length of the beam. This antler bears two short brow tynes, and shows only one bifurcation of the beam above; but the terminal fragment of another specimen, evidently of an older individual, exhibits a second bifurcation at the apex of the beam. There is no evidence in any fragment of an expanded crown or palm. Some of the smaller antlers have only one brow tyne, and in one malformed case this is abnormally bifurcated. A simple pricket, wanting the extreme tip, measures 0.2 in length. The surface in all specimens is more or less ridged and furrowed longitudinally, and there is a slight burr at the base.

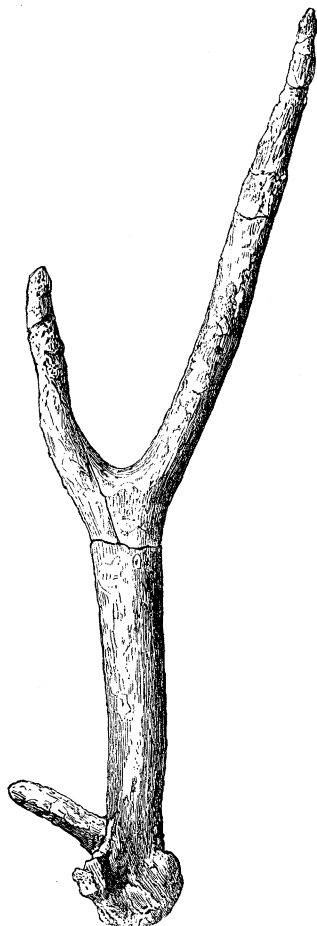


FIG. 2.—Antler of *Cervus elaphus*, var. *barbarus* ; one-fifth natural size.

Jaws are numerous, and there are a few portions of skull, apparently broken during excavation. The following measurements of the teeth indicate their maximum size, and will serve for comparison :—

Length of upper	m. 1, 0·013 ;	m. 2, 0·017 ;	m. 3, 0·017.
„ lower	pm. 2, 0·010 ;	pm. 3, 0·012 ;	pm. 4, 0·012 ;
	m. 1, 0·014 ;	m. 2, 0·017 ;	m. 3, 0·023.

Of the very variable limb bones the following maximum and minimum measurements of length in adult specimens are worthy of record :—

	Maximum.	Minimum.
Length of humerus	0·19	0·17
„ radius	0·215	0·175
„ metacarpus	0·19	0·16
„ femur	0·215	0·21
„ tibia	0·26	0·22
„ metatarsus.....	0·203	0·18
„ calcaneum	0·095	0·063
„ astragalus	0·04	0·035

The small dimensions of all these Cervine remains suggest a comparison at first with the common Fallow Deer (*Cervus dama*); and it is quite possible that some specimens—notably those from Excavation No. IV—may represent this southern European form, which has already been recognised by Busk in the caverns of Gibraltar. The limb bones, however, appear to the present writer to be slightly more robust than those of the Fallow Deer of corresponding size; and the antlers conclusively prove that most of the remains, at any rate, do not belong to this species. The antlers may be assigned with certainty to the small variety of *Cervus elaphus* which now lives in Northern Africa, and is known as the Barbary Deer (*Cervus barbarus* of Gray); the Maltese fossils, however, indicate an animal of smaller dimensions than its existing representative and its contemporaneously discovered in the caverns of Gibraltar.

“The Effects of Mechanical Stress on the Electrical Resistance of Metals.” By JAMES H. GRAY, M.A., B.Sc., and JAMES B. HENDERSON, B.Sc., “1851 Exhibition” Science Scholars, Glasgow University. Communicated by LORD KELVIN, P.R.S. Received February 10,—Read March 2, 1893.

This investigation was begun under the instructions of Lord Kelvin about a year ago, and has been continued since the beginning of last year in conjunction with another on thermal conductivity, for which a grant of £50 was made from the Government Research Fund.

The chief object of the investigation was to obtain quantitative results of the variations of specific resistances of metals due to stretching, twisting, drawing through holes in a steel plate, hammering, heating, and combinations of these, while in some of these cases the alteration of density was also measured.

The most exhaustive results that have been hitherto given in this direction are those of Lord Kelvin, published in vol. 2 of his ‘Re-

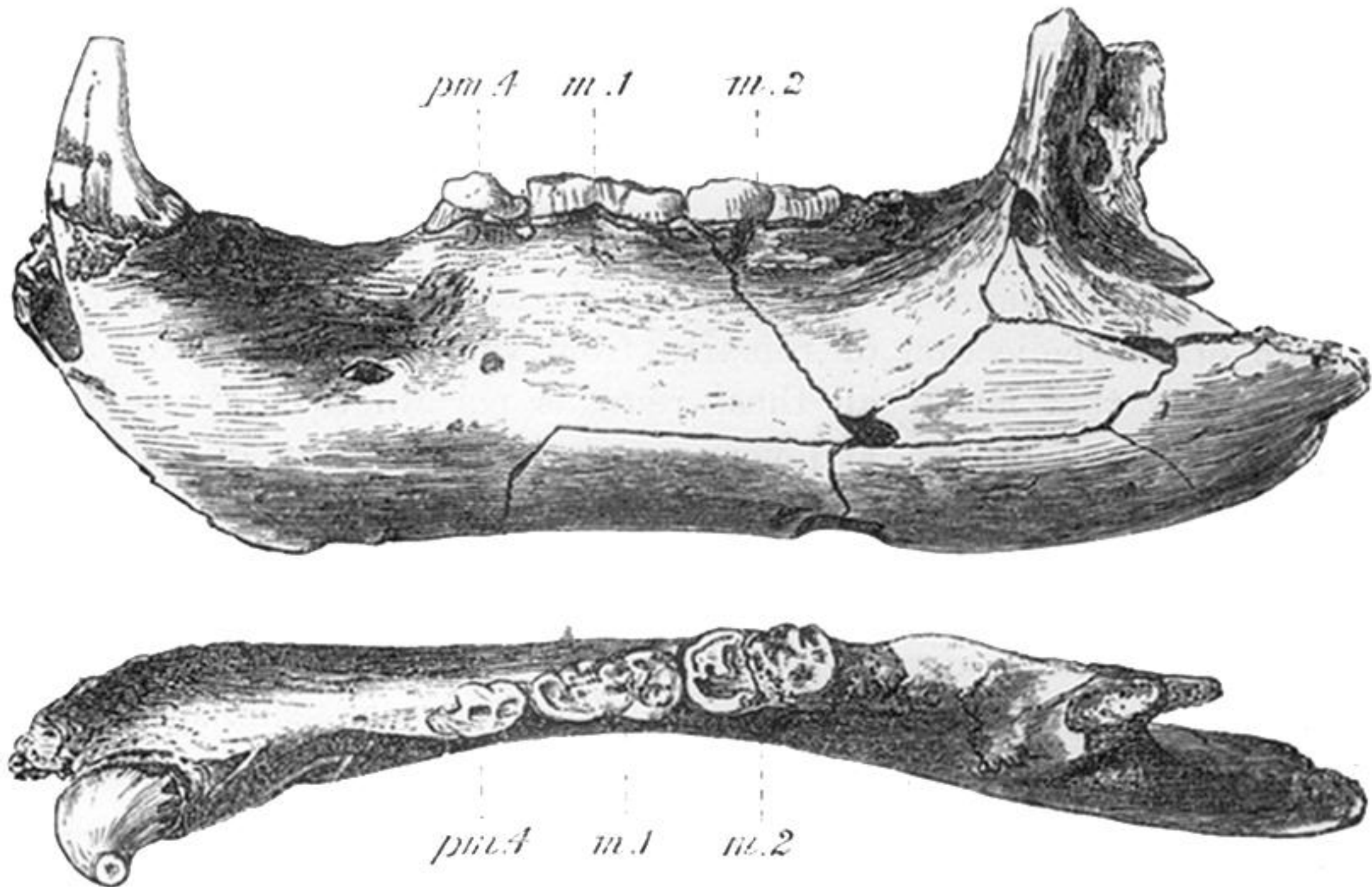


FIG. 1.—Left Mandibular Ramus of *Ursus arctos* (?) ; one-half natural size.

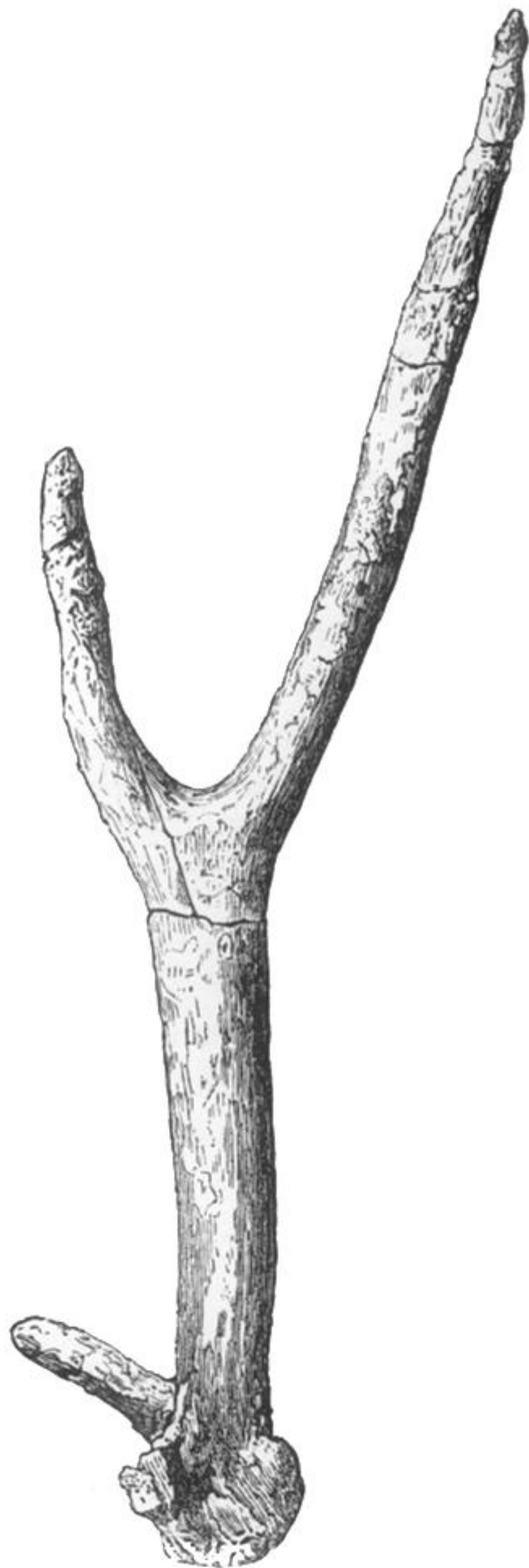


FIG. 2.—Antler of *Cervus elaphus*, var. *barbarus* ; one-fifth natural size.